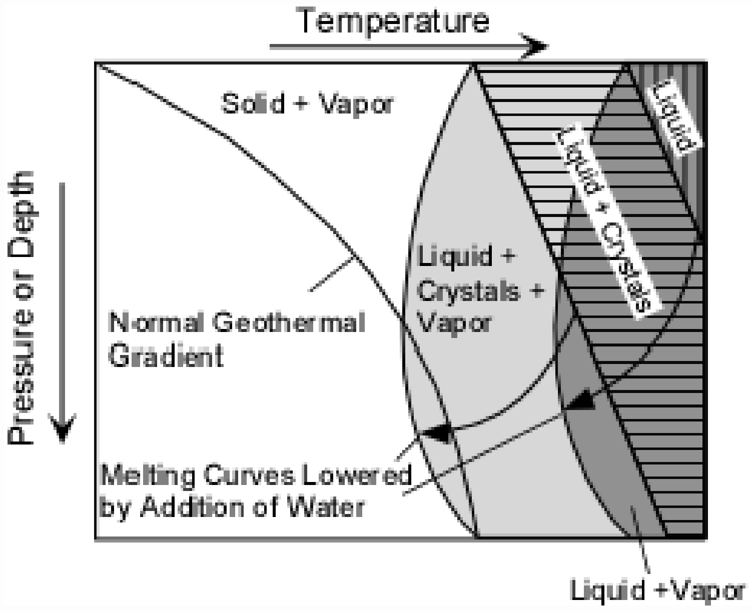
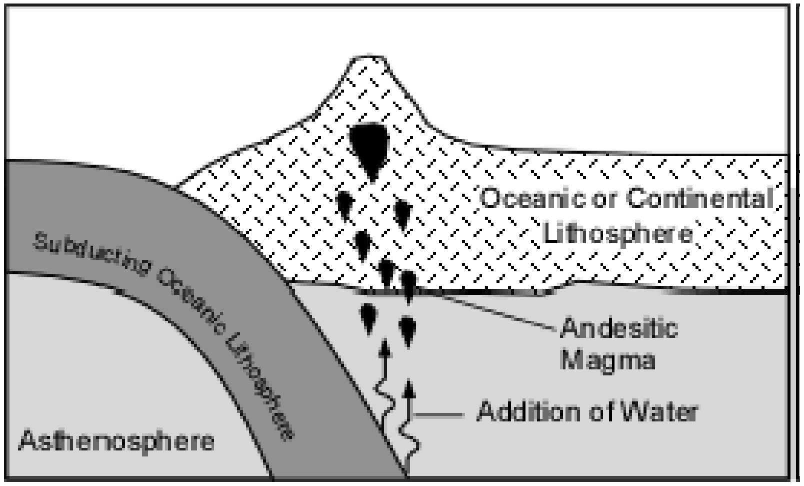
Origin of Andesitic Magma

- Andesitic magmas erupt in areas above subduction zones. This suggests a relationship between the production of andesitic magma and subduction.



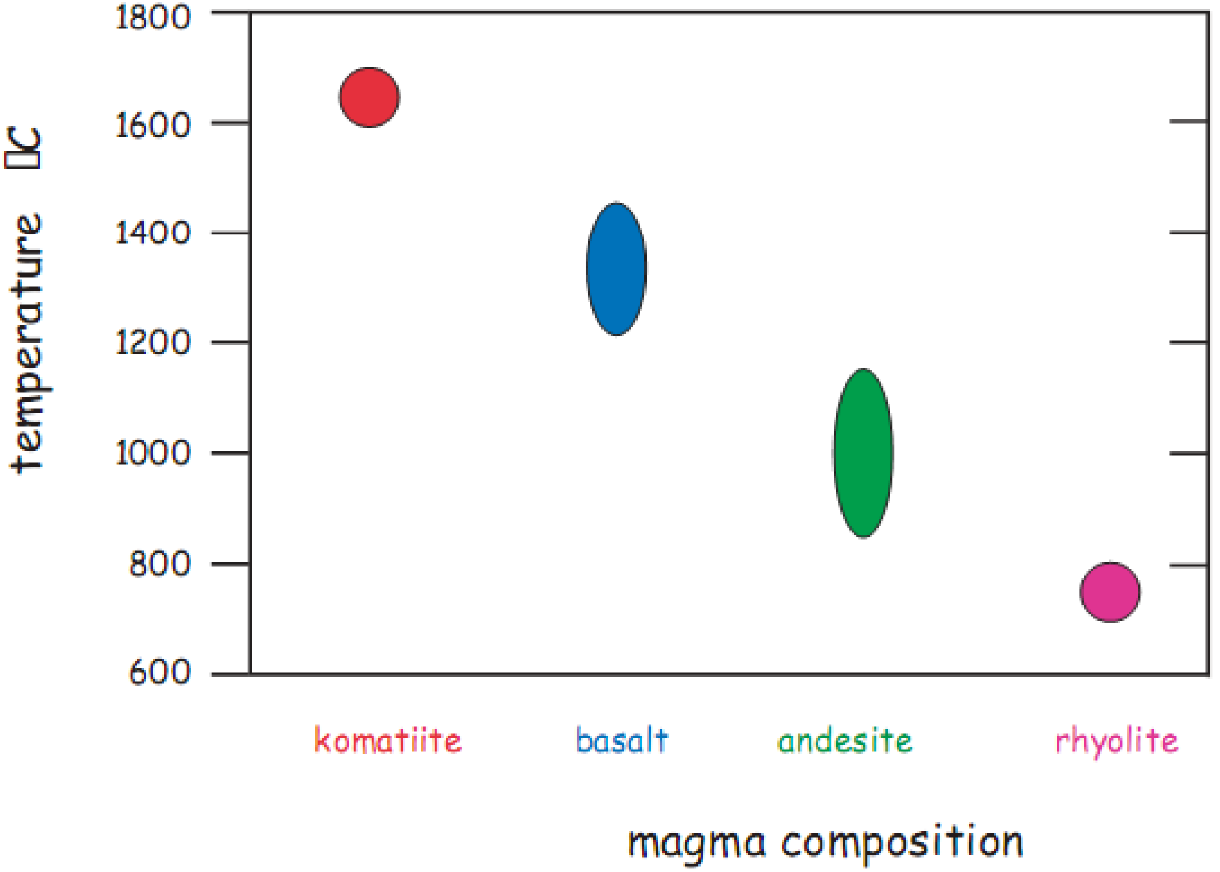

Oceanic or Continental Lithosphere
Subducting Oceanic Lithosphere
Andesitic Magma
Addition of Water
Asthenosphere

Physical Properties of magma depend on:

- **Temperature**
- **Density**
- **Volatile Content**
- **Viscosity**

BY : JHONNY

What are common magmatic temperatures?



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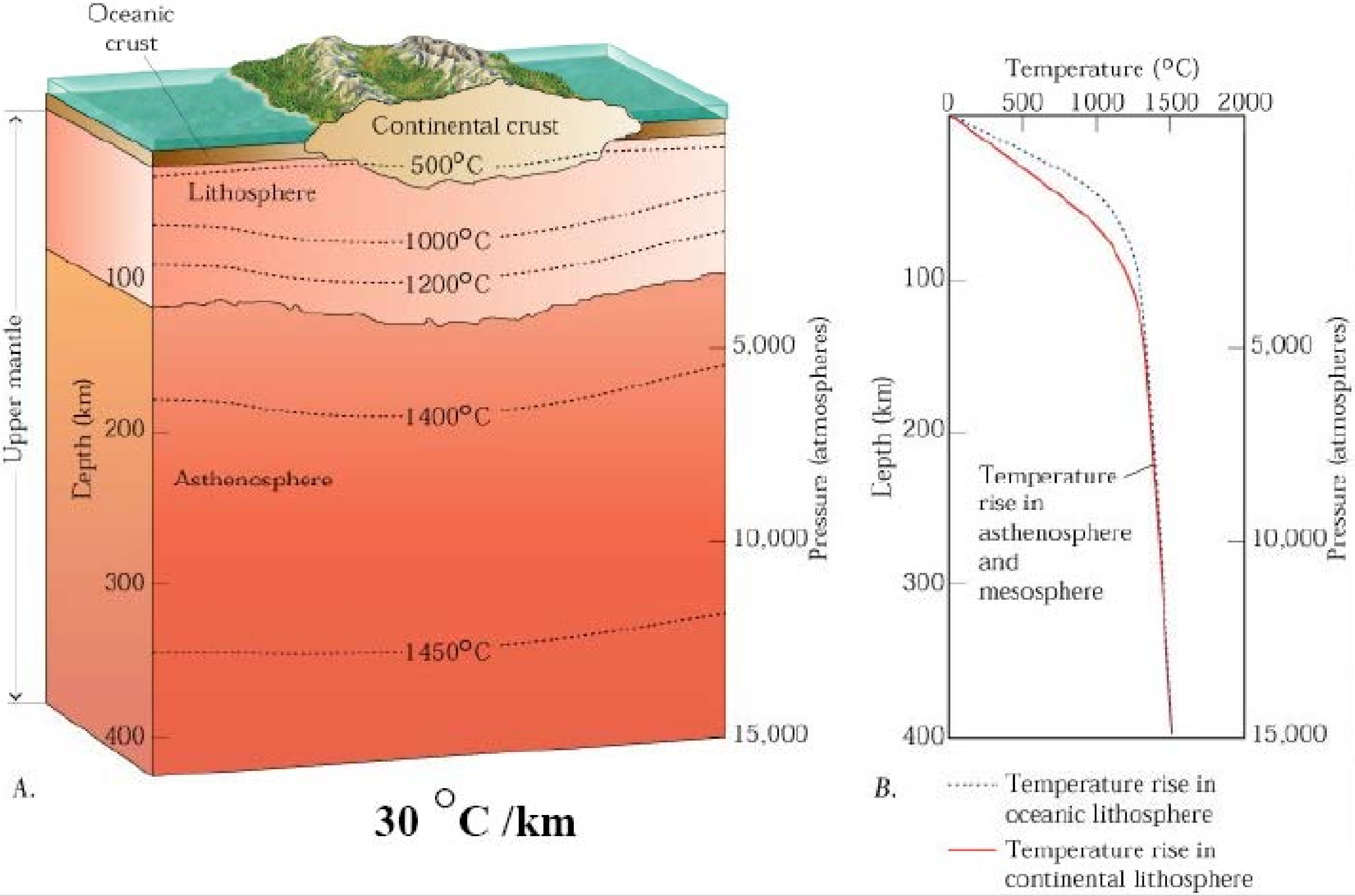
TEMPERATURE

Basalt @ 1 atm: 1200-1250^{o}C liquidus, 950-1000^{o}C solidus.

Rhyolite:
Liquidus = 1050^{o}C
Hydrous solidus (with H_2O) = 650 ^{o}C
Anhydrous solidus (no H_2O) = 750^{o}C

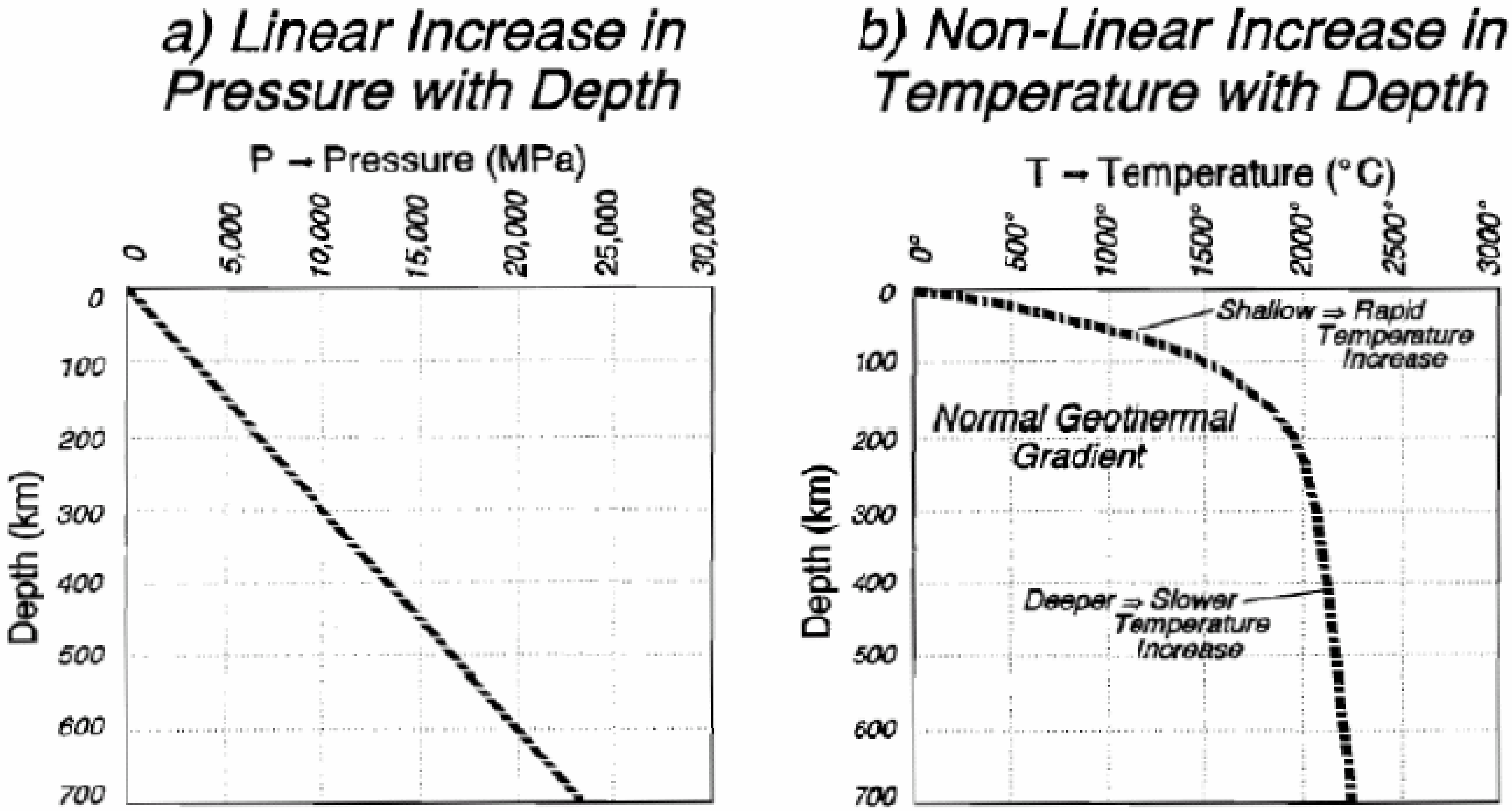
>> Rhyolite solidus defined as T where viscosity $>10^{13}$ poise.
>> Determined experimentally.

Geothermal Gradient



30 °C /km

Geothermal Gradient

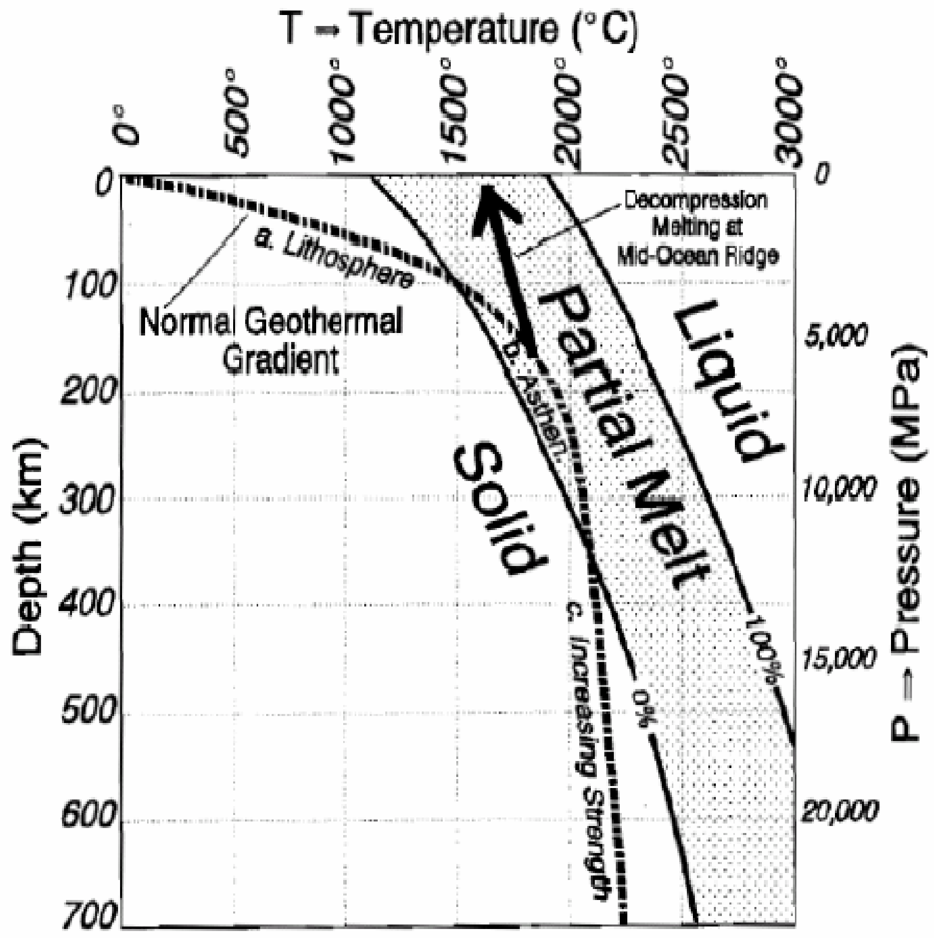


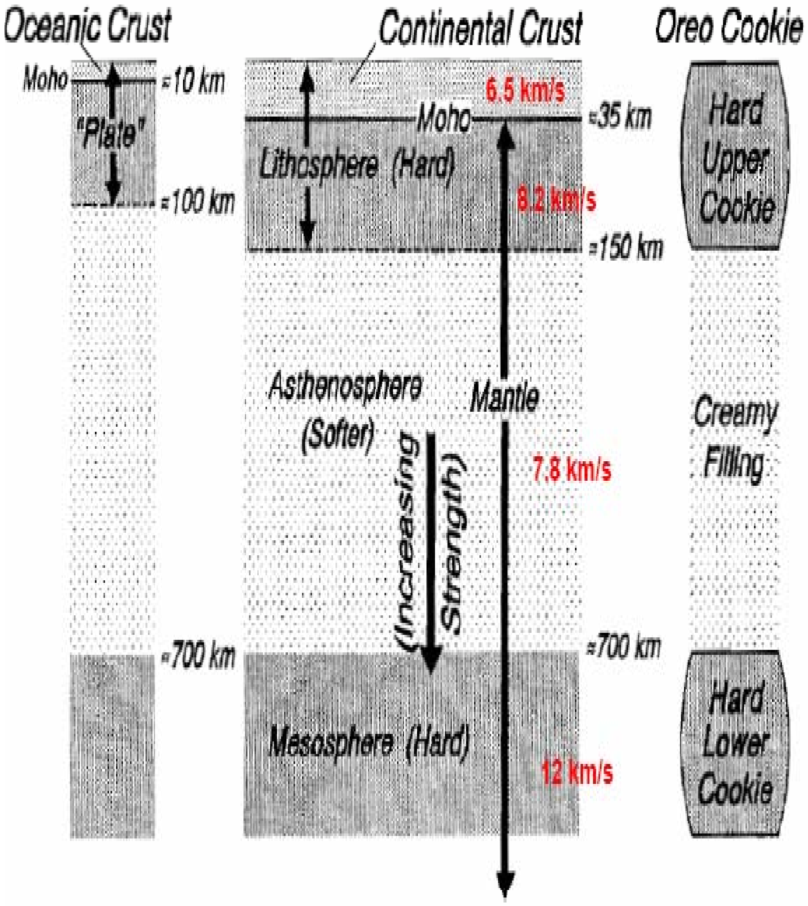
a) Linear Increase in Pressure with Depth

b) Non-Linear Increase in Temperature with Depth

FIGURE 2.6 Pressure and temperature in Earth's upper 700 km. Modified from *Physical Geology* by Skinner/Porter, © 1987, with permission of John Wiley and Sons, Inc., New York.

Geothermal Gradient





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DENSITY

Density controlled by magma composition: **FeO wt%** most important.

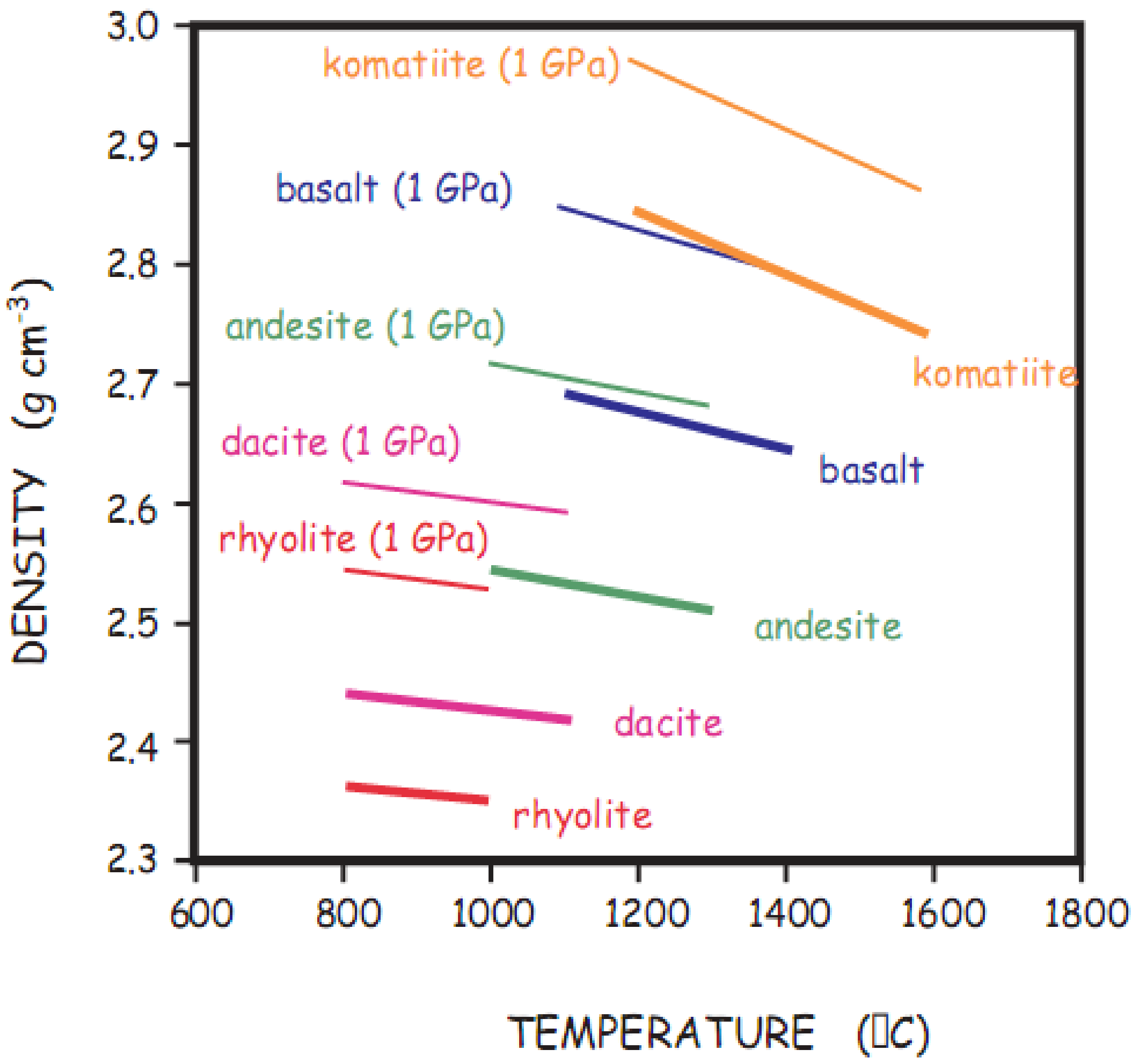
In general, basalts are richer in Fe, Ca, and Ti than rhyolites; rhyolites are richer in Na, Al, and Si than basalts:

Basalt magma: 2.65 to 2.80 gm/cm^3
Andesite magma: 2.45 to 2.50 gm/cm^3
Rhyolite magma: 2.18 to 2.25 gm/cm^3

Density is also controlled by *Temperature* and *Pressure*.

Higher *Temperatures* cause melts to Expand ===>> Lower Density

Higher *Pressures* cause the melts to Compress == >> Higher Density



komatiite (1 GPa)
basalt (1 GPa)
andesite (1 GPa)
dacite (1 GPa)
rhyolite (1 GPa)
komatiite
basalt
andesite
dacite
rhyolite
3.0
2.9
2.8
2.7
2.6
2.5
2.4
2.3
DENSITY (g cm^{-3})
600
800
1000
1200
1400
1600
1800
TEMPERATURE (C)

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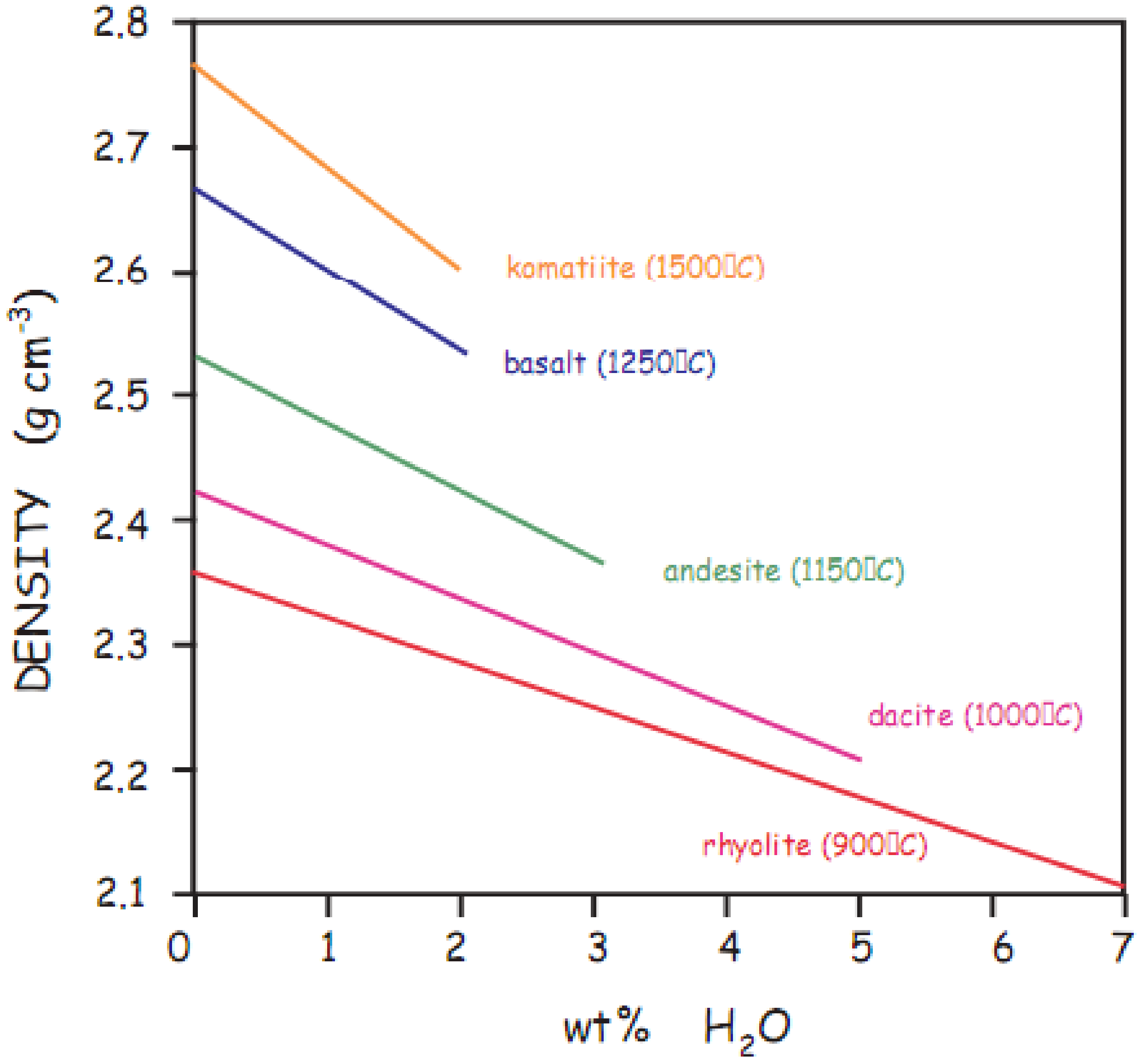
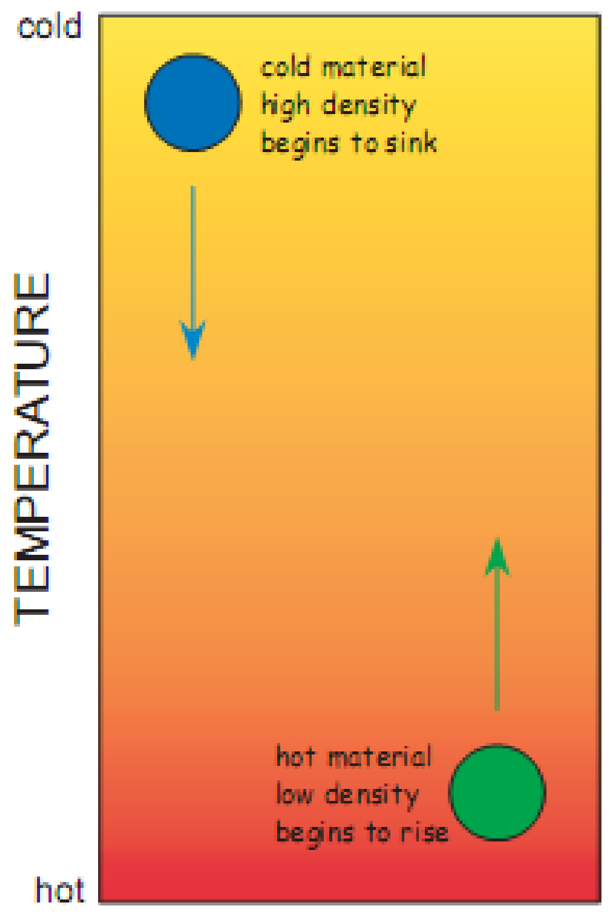

2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
DENSITY (g cm^{-3})
0
1
2
3
4
5
6
7
wt% H_2O
komatiite (1500□C)
basalt (1250□C)
andesite (1150□C)
dacite (1000□C)
rhyolite (900□C)

BY : JHONNY

Buoyancy is an upward acting force exerted by a fluid , that opposes an object's weight.

- magmas rise by buoyancy
- to reach the surface magma must be less dense than the surrounding rocks
- magmas more dense than the lithosphere may be "filtered" out (the lithosphere acts as a DENSITY FILTER).
- crystals forming in a magma will sink or float depending on their density and the density of the magma - important for fractionation of magmas (changing composition).
- magmas with equal densities can mix e.g. below ridges. Magmas with unequal densities form stratified magma chambers.



VOLATILES

- H_2O most abundant volatile in most magmas
- CO_2 next most abundant volatile

In general, **Basalt** magmas are DRY, i.e. $H_2O < 0.5$ wt%

MORB = 0.25% H_2O
Hawaiian Tholeiite = 0.5% H_2O
Alkali Olivine Basalt = 0.9% H_2O

Andesites, Rhyolites, Granites: Higher Water Contents

- Paricutin Andesite = 2.2% H_2O at 1100°C
- Granites/Rhyolites wide range H_2O: 0.5% to 7% H_2O by weight.

- Water lowers viscosity: OH^- ions act as Network Modifers, substitute for O_2 in tetrahedra.

- Water lowers solidus temperature: Effect greater at higher pressures

Magma Viscosity

- Some lavas flow easily e.g basalts, komatiites
- Others are very stiff and form spines and domes rather than flows e.g. rhyolite
- The property that describes resistance to flow is viscosity
- Viscosity is extremely important as it controls emplacement rates, shapes of intrusions, sinking / floating rates of crystals and the hazard that volcanoes represent to human life and activity

Key Concept: The viscosity of magma depends upon its silica content and temperature.

- **Silica** is a common substance in Earth's crust. Magma contains silica. Magma that contains more silica has higher viscosity.
- High-silica magma produces high-viscosity lava. This lava flows slowly. High-silica lava or magma cools to form rocks such as granite.
- Low-silica magma produces low-viscosity lava. This lava flows quickly. Low-silica lava cools to form rocks such as basalt.

- Hotter magma has lower viscosity than cooler magma.
- Very hot magma produces lava called **pahoehoe** (pah HOH ee hoh ee). Pahoehoe has low viscosity. It flows quickly. It hardens into a rippled surface.
- Cooler magma produces lava called **aa** (AH ah). Aa has high viscosity. It flows slowly. It hardens into rough chunks.